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Use of efficient microorganisms in agriculture

Utilização de microrganismos eficientes na agricultura

El uso de microorganismos eficientes en la agricultura

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Abstract
The interest in the use of microorganisms in agricultural practices has increased significantly in recent years, both in the promotion of plant growth and in the biological control of plant pests and diseases. This literature review work aimed to address information on the use of isolation, multiplication, use and storage methodologies for efficient microorganisms (Effective Microorganisms, EM) in agriculture. These microorganisms have important functions for their hosts, as they have symbiotic interactions with them, and are capable of protecting plants from attack by insects, diseases and herbivorous mammals through the production of toxins. The use of EM in agriculture aims to accelerate the natural composition of organic matter and promote the balance of microbial flora contributing to plant development. EMs are potential substitutes for chemical products, and can thus favor the preservation of the environment. They are collected from fertile forest soils through simple and inexpensive methodologies, consisting of a tool with potential to be used both by family farmers and on a small and large scale. They can be used in different ways, the main ones being in soil, plant, water and animals. The use of EM is an accessible and low-cost technique, in addition to being easy to prepare within the property itself, contributing to the sustainability of agricultural systems.
Keywords: Isolation; Multiplication; Storage; Sustainability.

Resumo
O interesse no emprego de microrganismos em práticas agrícolas aumentou significativamente nos últimos anos, tanto na promoção de crescimento vegetal como no controle biológico de pragas e doenças de plantas. O presente trabalho de revisão de literatura, teve como objetivo abordar informações sobre o uso de metodologias de isolamento, multiplicação, utilização e armazenamento de microrganismos eficientes (*Effective Microorganisms*, EM) na agricultura. Esses microrganismos possuem funções importantes para seus hospedeiros, pois apresentam interações simbióticas com o mesmo, e são capazes de proteger as plantas do ataque de insetos, de doenças e de mamíferos herbívoros por meio da produção de toxinas. O uso de EM na agricultura tem por objetivo acelerar a de composição natural de matéria orgânica e promover o equilíbrio da flora microbiana contribuindo para o desenvolvimento das plantas. Os EM são potenciais substitutos de produtos químicos, podendo favorecer desta maneira a preservação do ambiente. São coletados a partir de solos férteis de matas por meio de metodologias simples e baratas, consistindo em uma ferramenta com potencial para ser utilizados tanto por agricultores familiares quanto em pequena e larga escala. Podem ser utilizados de diferentes formas, sendo as principais no solo, na planta, na água e em animais. A utilização de EM é uma técnica acessível e de baixo custo, além de ser fácil o preparo dentro da própria propriedade, colaborando para a sustentabilidade de sistemas agrícolas.
Palavras-chave: Isolamento; Multiplicação; Armazenamento; Sustentabilidade.

Resumen
El interés por el uso de microorganismos en prácticas agrícolas ha aumentado significativamente en los últimos años, tanto en la promoción del crecimiento vegetal como en el control biológico de plagas y enfermedades de las plantas. Este trabajo de revisión de la literatura tuvo como objetivo abordar información sobre el uso de metodologías de

aislamiento, multiplicación, uso y almacenamiento de microorganismos eficientes (microorganismos efectivos, EM) en la agricultura. Estos microorganismos tienen funciones importantes para sus huéspedes, ya que tienen interacciones simbióticas con ellos y son capaces de proteger a las plantas del ataque de insectos, enfermedades y mamíferos herbívoros mediante la producción de toxinas. El uso de EM en la agricultura tiene como objetivo acelerar la composición natural de la materia orgánica y promover el equilibrio de la flora microbiana que contribuye al desarrollo de las plantas. Los ME son sustitutos potenciales de los productos químicos y, por tanto, pueden favorecer la preservación del medio ambiente. Se recolectan de suelos forestales fértiles mediante metodologías simples y económicas, que consisten en una herramienta con potencial para ser utilizada tanto por agricultores familiares como a pequeña y gran escala. Se pueden utilizar de diferentes formas, siendo las principales en suelo, plantas, agua y animales. El uso de EM es una técnica accesible y de bajo costo, además de ser fácil de preparar dentro de la propia propiedad, contribuyendo a la sostenibilidad de los sistemas agrícolas.
Palabras clave: Aislamiento; Multiplicación; Almacenamiento; Sustentabilidad.

1. Introduction

The modernization of agriculture began in the mid-1960s and provided an increase in the productivity of Brazilian crops. Currently, Brazil is considered one of the largest food suppliers in the world (Saath & Fachinello, 2018). Knowing that natural resources are limited, more sustainable food production methods are essential to ensure food security for the constantly growing population (Gabardo et al., 2020; EMBRAPA, 2021; Macoski et al., 2021; Clock et al., 2021).

In this way, the microorganisms present in the soil can be used as a tool to provide nutrients and protect plants against pathogens. They are called efficient microorganisms (*Effective Microorganisms*, EM), a microbial community formed by fungi and bacteria from forest soils and with beneficial potential for plant development (Teixeira et al., 2017).

The interest in the use of EM in agricultural practices has increased significantly in recent years, both in the promotion of plant growth and in the biological control of plant pests and diseases, among other applications, they constitute potential substitutes for chemical products, and may thus favor preservation of the environment (Domenico, 2019).

EM are collected from fertile forest soils through simple and inexpensive methodologies (Benites et al., 2010), consisting of a tool with potential to be used both by family farmers and on a small and large scale. In view of this, and the growing concern with the environmental problems generated by the agricultural production processes used over the last decades, there is a need for research to point out the real benefits of EM on plants and on the soil (Golec et al., 2007; Mayer et al., 2010).

Another relevant factor is the drop in the efficiency of chemical products, and the increasing cost has driven the market for biological inputs (De Melo et al., 2021). The research of new production systems methodologies is important to make the microbial control of agricultural diseases and pests economically viable to be applied. New research results are always needed and have helped to improve small and large-scale production, formulation, storage and field application techniques (Alves & Faria, 2010).

Within this context, the objective of this work was to gather information on the use of isolation and activation methodologies and the use of efficient microorganisms, to obtain, in a simple and systemic way, their production, contributing to the rational and sustainable control of pests and diseases farmers in the region and the future prospects of this biotech tool.

2. Methodology

The present study is a systematic bibliographic review in different scientific electronic databases, through descriptors related to the isolation and production of microorganisms "On Farm" in Brazil. The identification and inclusion of studies was carried out during the first and second semester of 2021.

The bibliographic search was carried out in the following electronic databases: Periodical CAPES/MEC and Scientific Electronic Library Online-Scielo. The other additional information was obtained from a manual search based on the observed references and listed in the articles included and in journals in the systematic review study. As it is a current theme, sources for texts from newspapers and magazines can also be inserted.

Searches were conducted using descriptors, in Portuguese and English, based on the terms contained in the titles or on the key words and abstracts of the studies. The combination of terms used together or even separately, in the respective databases (Periódicos capes/MEC and Scielo) were:

"Microrganismos eficientes (Effective Microorganisms)"

"Agentes de biocontrole (Biocontrol agents)";

"Bactérias endofíticas (Endophytic bactéria)";

"Fungos endofíticos (Endophytic fungi)";

"Microrganismos endofíticos (Endophytic microorganisms)";

"Interação entre microrganismos endofíticos e seus hospedeiros (Interaction between endophytic microorganisms and their hosts)";

"Microrganismos endofíticos em controle biológico de patogenias (Endophytic microorganisms in biological control of pathogens)";

"Aplicação de microrganismos endofíticos na agricultura (Application of endophytic microorganisms in agriculture)";

"Microrganismos endofíticos como agentes de biocontrole (Endophytic microorganisms as biocontrol agents)";

"Controle biológico microrganismos endofíticos (Biological control endophytic microorganisms)";

"Microrganismos eficientes (Efficient microorganisms)";

"Agricultura microrganismos eficientes (Agriculture efficient microorganisms)";

"Microrganismos eficientes benefícios (Efficient microorganisms benefits)";

"Microrganismos benéficos (Beneficial microorganisms)";

"Defensivos agrícolas biológicos (Biological pesticides)";

"Microrganismos na agricultura (Microorganisms in agriculture)";

"Microrganismos na agricultura controle (Microorganisms in control agriculture)";

"Controle biológico microrganismos endofíticos (biological control endophytic microorganisms)";

"Interesse econômico microrganismos endofíticos (Economic interest endophytic microorganisms)";

"Potencial biotecnológico controle biológico (Biotechnological potential biological control)";

"Microrganismos endofíticos potencial biotecnológico (Biotechnological potential endophytic microorganisms)";

"Compostos inseticidas microrganismos endofíticos (insecticidal compounds endophytic microorganisms)";

For selection of articles or texts from newspapers, a table will be produced with the following information: author and year, geographic scale of coverage, study design and main results. Then, an analysis of the information obtained will be performed through a systematic review, preparation of a scientific article as well as publication in scientific journals and participation in correlated events.

3. Efficient Micro-Organisms

Microorganisms that live inside plants and generally inhabit their aerial parts, such as leaves and stems, but apparently do no harm to their hosts, are called endophytes. In addition to playing several important roles for the host, these microorganisms are potentially useful in agriculture and industry, especially in pharmaceuticals and pesticides (Dos Santos & Varavallo, 2011).

Complex adaptive mechanisms, evolutionarily, have been developed by plants; many of them are only possible thanks to interactions with microorganisms, among which the endophytic ones stand out (Peixoto et al., 2004). They were first mentioned in the beginning of the 19th century, however, it was only in the late 70s of the 20th century that they began to be treated with greater emphasis in scientific works.

Studies have shown that these microorganisms have important functions for their hosts, as they have symbiotic interactions with them, and are capable of protecting plants from attack by insects, diseases and from attack by herbivorous mammals through the production of toxins (Azevedo et al., 2000). Endophytic microorganisms mainly include fungi and bacteria that live inside plants, generally inhabiting their aerial parts, such as leaves and stems, without apparently causing any damage to their hosts (Assumpção et al., 2009).

This differentiates them from phytopathogenic microorganisms, which are harmful to plants and cause them disease. They are also distinct from epiphytic microorganisms, which live on the surface of plant organs and tissues (Souza et al., 2004). Endophytic microorganisms are potentially useful in agriculture and industry, particularly in food and pharmaceuticals; several selected species of endophytes have potential employment in the pesticide industries (Dos Santos & Varavallo, 2011).

Endophytic microorganisms are potential sources of natural, bioactive and chemically new products for exploration in medicine, agriculture and industry (Strobel & Daisy, 2003; Tejesvi et al., 2007). There has been growing interest in studies on the occurrence, colonization potential and use of endophytic bacteria to promote growth and biological control of plant diseases (Hallmannet et al., 1997; Amorim & Melo, 2002).

Bacteria in natural habitats colonize the interior and exterior of plant organs and can be beneficial, neutral or detrimental to their growth (Mariano et al., 2004). The use of endophytic bacteria in agriculture represents an unquestionable potential, through the first publications with endophytics it was possible to demonstrate that the presence of these microorganisms resulted in the reduction of damage caused by phytophages (Oki et al., 2009).

Research indicates that the endophytic bacteria are not subject to competition for nutrients that normally occurs in the rhizosphere, and are more efficient than the bacteria that colonize the rhizosphere in promoting growth, water absorption and suppression of harmful microorganisms because they are within the root system (Amorim & Melo, 2002).

Studies involving endophytic microorganisms in plant growth promotion in Brazil have already been carried out with maize (*Zea mays*) and tobacco (*Nicotiana tabacum*) (Varma et al., 1999), peppermint (*Mentha piperita*) (Mucciarelli et al., 2003), yellow passion fruit. (*Passiflora edulis*) (Luz et al., 2006), pine cone (*Annonas quamosa*) (Silva et al., 2006), tomato (*Solanum lycopersicum*) (Barretti et al., 2008) and pineapple (*Anana scomosus*) (Baldotto et al., 2010), showing promising answers.

4. EM Collection Process

EM can be purchased commercially and/or collected on the rural property. When collected on the property, EM must be captured in healthy soil, forest soils, in the agricultural unit (on the land where the family lives), or in a nearby area. The efficient microorganisms in each region are more adapted to local conditions, facilitating the process of rebuilding the living soil (Andrade et al., 2020).

According to the ME collection method by Bonfim et al. (2011), 700 g of cooked rice without salt and without seasoning is placed in a pet bottle cut in half and placed under the forest floor and covered with litter, these baits can be removed after seven to 10 days of installation.

By the method of Andrade et al. (2020), for the preparation of EM that followed the method of Bonfim et al. (2011), but according to Andrade et al. (2020), first, the collection of soil and litter is carried out with the aid of a garden rake and hoe. Therefore, it is necessary to select locations in the forest where the litter is in a more advanced state of degradation, in addition to observing the presence of filamentous fungi. With the help of a garden rake, the litter is separated from the soil, removed and stored in plastic bags. Afterwards, the soil is removed with the help of a hoe and also stored in plastic bags.

After collecting the soil and litter from the forest, the assembly of the "baits" to capture EM begins. The "baits" are mounted in a plastic organizer box with a capacity of 12 liters. First a layer of soil of approximately 3 cm is placed covering the entire bottom of the box, then the soil is covered with a cotton cloth previously scalded in boiling water for approximately 5 minutes. Then, a layer of 700 g of cooked rice without salt and without seasoning is placed, which serves as a substrate for the capture of EM according to Bonfim et al. (2011).

Thus, the rice is covered with a cotton cloth previously scalded and the litter placed on top until it reaches the maximum capacity of the box. Finally, the box must be sealed with a cloth, to prevent the entry of flies and other insects. After ten to fifteen days of incubation, EM should have colonized the rice. The rice color varies depending on the type of forest where the microorganisms were captured. The more diversified and structured the forest, the more colors will be present, the more colorful the better. Once the EM are captured, activation must be performed (Hu & Qi, 2013; Iriti et al.,2019)

5. Activation and Storage of EM

The EM activation step is performed after EM capture since the different communities of microorganisms must coexist in a liquid medium. For activation, distribute the colored rice in about 5 2-liter plastic bottles. Put 200 mL of molasses in each bottle and fill the bottles with clean water (without chlorine) or rice water.

Close the bottles and leave them in the shade for 10 to 20 days. Release the gas (open the lid) stored in the bottles every 2 days. Place the cap and squeeze the bottle from the sides, removing the air that remained inside the bottle (the fermentation must be anaerobic, that is, without air, without the presence of oxygen). Tighten the lid tightly (Andrade et al., 2020).

The gas formed by fermentation must be released daily. Efficient microorganisms are ready when gas formation ceases and the pH of the solutions is between the values of 3.2 and 3.5 (Tanya & Leiva, 2019).

EM is colored to orange. It can be lighter or darker, which depends on the raw material, but does not imply the quality of the product. The smell is sweet pleasant. In case of bad odor, EM should not be used. Once ready, it can be stored for up to 1 year (Raouche et al., 2011).

Some precautions must be followed at this stage, such as water treated with chlorine (street water, city water) must be previously placed in an uncapped container. Only after 24 hours the water can be used. That's because chlorine kills microorganisms. Mine water is used directly (Andrade et al., 2020).

Molasses (can be replaced by sugarcane juice) is food for microorganisms. Therefore, it makes the active microbial community grow, which, through fermentation reactions, produce organic acids, plant hormones (gibberellins, auxins and cytokinin), in addition to vitamins, antibiotics and polysaccharides, enriching the solution (Souza et al., 2015).

6. Composition of EM

Efficient microorganisms are very small beings (fungi and bacteria) that live naturally in fertile soils and plants. Efficient microorganism cultures are formed by different groups of microorganisms found in the soil, namely lactic acid bacteria, yeasts, photoautotrophic bacteria, fermenting fungi and actinomycetes. Additionally, the soil microbiota is very variable, since the soil cannot be considered as a single and homogeneous environment. This environment is subject to biotic and abiotic factors that interfere with the microbial community in each plot of soil (Fierer, 2017).

Bacteria of the Firmicutes phylum are commonly found in the soil (Cardoso & Andreote, 2016), and play important functions of agricultural interest. The predominance of the Bacillus genus was observed by Bomfim (2011), species of this genus are widely reported as plant growth promoters as they are capable of synthesizing phytohormones such as auxins

(Batista, 2017) that act in plant development and growth. Another important reported genus is Lactoccocus, bacteria of this genus produce antimicrobial substances, including lactic acid, which contribute to the suppression of pathogens (Bomfim, 2011; Tanya & Leiva, 2019).

Tanya and Leiva (2019) sought to characterize the microbial community of EM home and commercial origin, the results indicate that the three EM analyzed shared the phyla Actinobacteria, Proteobacteria, Synergistetes, in addition to the phylum Firmicutes. In both studies it is possible to verify the predominance of bacterial communities in relation to the fungal community, in addition to verifying some prevalent bacterial genera in all evaluated EM (microbial core). This microbial core is basically composed of microorganisms from the genus *Bacillus*, *Streptomyces*, and *Staphylococcus*.

However, Santoyo et al. (2016) did not observe the presence of fungi through metagenomics in commercial EM. Furthermore, in relation to this fungal community, the sharing of operational taxonomic units (OTUs) was not observed among the collected homemade EM. Thus, it is possible to see that despite few studies on the microbial communities that make up the EM, it is observed that factors such as type of collection and soil of origin influence the composition of EM.

Iriti et al. (2019) point out that efficient microorganism cultures are mainly composed of lactic acid bacteria. These bacteria have important biotechnological functions applied to agriculture as they produce antibimicrobials and act by decomposing organic matter (Bonfim et al., 2011). The lactic acid produced by these bacteria acts to solubilize phosphate, an important nutrient for plant growth and development (Cui et al., 2021).

As already reported, the composition of EM can vary depending on the place of collection, but it maintains central communities (Andarade et al., 2020), capable of synthesizing antimicrobials such as some bacteria of the Bacillus genus and Actinobacteria (Barka et al., 2016). These antimicrobials are of great agronomic importance and should be explored as a mechanism of action against pathogens that affect major crops, thus seeking to provide sustainable means, replacing chemical treatments in crops with the use of biological products.

7. Use of EM

Efficient microorganisms work on organic matter and for this reason they have a wide range of activities (Tanya & Leiva, 2019; Andrade et al., 2020).

7.1 On Soils

All living beings coexist even with microorganisms. The basis that sustains the food chain is the soil where the smallest living beings live: microorganisms. Based on this concept, it was found that the use of EM contributes to the natural strengthening of the soil. Efficient microorganisms have been used in soil revitalization (Souza et al., 2015).

The presence of efficient microorganisms makes the soil richer in vital energy, making the soil's natural production capacity full. The soil manifests its strength and balance if it is always kept pure. The purer the soil is, the less artificiality, the greater its strength in plant development (Andrade et al., 2020).

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All microorganisms that coexist in EM do very important work, balancing the soil environment. There is control of harmful microorganisms, and useful microorganisms become more numerous. This soil environment favors agricultural production and diseases are unlikely to occur. The responses of soil treated with EM are mainly and directly (Amorim et al., 2002):

a) Restore healthy soil microbiota. The greater the quantity and diversity of life in the soil, the better the quality of food produced in agriculture will be. Reminder: plant diversity implies diversity of microorganisms in the soil.

b) Restore the physicochemical and microbiological conditions of the soil.

c) Encourage the full emergence of plants (including medicinal plants and companion plants) facilitating soil management and coverage.

d) Act together with green manure to reduce soil compaction.

e) Increase: aggregation, soil porosity, water infiltration, available soil water and rooting depth. As a consequence, there is a reduction in erosion and in the frequency of irrigation.

f) Facilitate the decomposition of organic matter. Favor mineralization and availability of essential nutrients for plants.

g) Allow the reduction of chemical fertilizer or dispense with application.

h) Bioremediate contaminated soils by neutralizing heavy metals and pesticide residues. Via compost it can also neutralize petroleum residues and other oils.

i) Decrease or eliminate soil diseases and pathogens.

j) Speed up the waste composting process.

The use of efficient microorganisms in agriculture depends on the area, soil quality, climate, cultivation and irrigation methods, among other factors; With the application of beneficial microorganisms, the soil retains more water, which implies an improvement in crops that increase their resistance to water stress in times of drought or on more sandy soils; This improvement is due both to the increase in soil organic matter, reducing porosity, due to microbial activity, and to the ionic balance, favoring the interaction of the surface charges of the soil's physical structure with the ionic charges (Hoyos et al., 2008).

Most of the time, EM will need to be diluted and can be used in a variety of ways. It depends on available equipment, crop stage, soil preparation, and other uses. Every 1 liter of EM dilute in 1000 liters of water. The EM/soil (soil application solution) is ready. Reminder: Chlorine-treated water must be placed in an uncapped container the day before, for 24 hours. The next day add the EM. Chlorine kills microorganisms (Andrade et al., 2020).

7.2 In plants

The different species of microorganisms that make up EM produce organic acids, plant hormones (gibberellins, auxins and cytokinins), in addition to vitamins, antibiotics and polysaccharides. All these products exert, directly or indirectly, a positive influence on plant growth. EM 18 is used in the cultivation of vegetables, cereals, fruits and flowers for the following reasons (Baldoto et al., 2010):

a) Improves plant metabolism (example: photosynthetic capacity).

b) Activates root growth.

c) Increases germination, flowering and fruiting.

d) Activates the maturity of fruits and grains.

e) Apply foliar fertilization (similar to nitrogen fertilization).

f) Increases agricultural productivity.

g) Improves the quality of harvested products (increases protein, oil and grain weight).

h) Reduces the damage caused by consecutive planting.

i) Reduces insect damage.

j) Eliminates the use of insecticides due to greater plant resistance (especially when associated with homeopathy)..

The spraying of plants is done with the "EM/Plant." How to produce the "EM/Plant?" Add in 100 liters of EM/soil, ½ liter of vinegar. The EM/plant is ready. It is indicated after germination or in established cultures. Apply via foliar sprays or via watering can. Apply weekly until soil structure improves or plant health improves. Then do fortnightly sprays. In the year that EM is started, the number of applications is higher. If plant growing conditions are in order, year after year, the frequency may decrease. Spray in the morning or after rain (Yuan et al., 2011)

Dourado (2018) performed the "blotter" type health test with corn seeds treated with different concentrations of EM, the cultures were also filtered in order to obtain only the metabolites produced by the microbial communities, the results were promising, showing that both the EM and its metabolites at the concentration of 100% decreased the incidence of phytopathogenic fungi in corn seeds between 67% and 21% compared to the control. Furthermore, the same study isolated the non-pathogenic microorganisms found in the treated corn seeds and performed a test of paired cultures with *Fusarium verticillioides*, of 42 isolates from seeds treated with EM 21 reduced the mycelial growth of *F. verticillioides* through antagonism mechanisms, competition and antibiosis.

Other works also suggest that the use of EM can improve photosynthetic efficiency and thus increase production yield (Iriti et al., 2019). Jalil et al. (2017) did not obtain significant results when using EM alone, but associating the use of efficient microorganisms and NPK reduced the use of chemical fertilizer by half.

It is known that the interactions that occur in the rhizosphere between plants and microorganisms are complex and subject to several factors, and the plant's defense responses can modify the associated microbial structure (Toju et al., 2018).

Efficient microorganisms can occupy different niches in the root zone and, thus, compete for space and nutrients, limiting the development of phytopathogenic species. Likewise, the suppressive activity of efficient microorganisms can be exerted through the production of compounds with antimicrobial activity (antibiotics and antifungals), production of siderophores, induction of resistance, production of metabolites, antibiosis, activation of antioxidant systems in plants, activation of genes of resistance in plants (Schlatter et al., 2017).

7.3 In water

Efficient Microorganisms accelerate the natural decomposition of organic compounds that pollute water. EM produce bioactive substances that act on putrefaction pathogens and the production of harmful gases that contaminate water and cause bad odours. EM is useful in water decontamination and restores the natural balance of the aquatic system with beneficial and sustainable effects (Dos Santos et al., 2011).

Mix 1 liter of EM in 1,000 liters of water to be treated. Observe the water for 1 to 6 months. If necessary, repeat the application and wait for the next month. Upon achieving the expected results, there is a need for system maintenance. Monthly apply 1 liter of EM per 10,000 liters of water. The method of application, as well as the dosages, may vary according to local system conditions. In running water can also be used. Think about the costs, how to apply, the involvement with your neighbors and the whole community (Andrade et a., 2020).

7.4 In environmental sanitation

Efficient Microorganisms reduce the environmental impacts of industries because they act in the decomposition of waste and effluents. Using EM in waste is possible (Dos Santos et al., 2011; Amorim et al., 2007):

a) Controlling bad odors in the facilities

b) Eliminate the unpleasant smell of waste, reduce the production of harmful gases such as hydrogen sulphide (H_2S) and methane. Any type of organic matter can be composted with EM as there is no production of offensive odors.

c) Help control dust.

d) Promote rapid natural decomposition (4 to 6 weeks) of organic matter, naturally treating the slurry.

In rural areas, the agricultural family uses EM in the treatment of sewage and septic tanks. There is a reduction in bad smell and flies. The agricultural family is aware of and committed to Nature (Andrade et al., 2020).

7.5 In composting

EM can be used in the composting of waste from different sources. It is mainly indicated in the composting of slow decomposition waste, such as: waste with a high C/N ratio (woody parts of the plant, trunks, branches, straws), grasses, fats, among others. EM accelerates decomposition by reducing composting time (Iriti et al., 2019).

7.6 In animals

EM improves the livestock management environment by reducing stress and improving the quality of life of animals. Do not use EM as a medicine or vaccine. Use as a means of improving the environment (inside and outside the animal husbandry facility). Use in order to improve the animals' organism. EM is a living being. With EM it is possible to obtain conditions very close to those found in Nature, improving the quality of life of animals, because (Dos Santos et al., 2011):

a) Controls unpleasant odors in facilities with animals (swine farms, aviaries, kennels).

b) Cleans and eliminates odor in animals (bath with EM solution).

c) Source of vitamins and other nutrients.

d) Decreases flies and ticks.

e) Improves bed maintenance (increase in bed use period and cost reduction).

f) Improves the quality of agricultural products and the post-harvest shelf life.

g) Reduces the use of disinfectants and medications.

h) Reduces costs.

i) The animal is healthier and better looking. When applied to pasture, EM/soil activates pasture growth, increasing food availability to animals.

7.7 Other uses

EM is used in house cleaning: floors, walls, tiles, windows, toilets, sink drains, grease trap. EM removes grease and bad odor, enabling a clean and harmonious environment. What's the advantage? Abandon cleaning chemicals, toxics and environmental pollutants. Another advantage? The reduction in cases of allergy or poisoning among household residents (including pets and livestock) (Embrapa et al., 2021).

EM can also be used for washing clothes. EM does not eliminate stains, but eliminates “that sweaty smell” impregnated in used clothes (such as, for example, the “bed linen”). EM removes much of the rust in machinery and installations (Andrade et al., 2020).

8. Care When Storing and Applying EM

Store in a cool, well-ventilated place. Use the solution on the same day of preparation, preferably. Do not spray at times of strong sun, spray in the morning, very early in the morning, in the late afternoon or on cloudy days (Andrade et al., 2020).

Microorganisms are very sensitive to drought, so in the summer, when the sun is very strong, the application should be made at dusk or on cloudy days. The ideal is to apply before and after the rain, when the soil is damp. If the application of EM burns the edges of the leaves, use a lower concentration (Souza et al., 2015).

Do not use chlorinated (city) water immediately. Separate the container with water and after 24 hours obtain the EM solution. EM applications can be made in conjunction with biofertilizers. The sprayer or watering can used with pesticides must be washed with soap and water, several times, until all the pesticide is removed. If possible, buy new, separate and leave it to the EM alone (Santoyo et al., 2016).

The application of EM will have better results if other Organic Agriculture techniques are observed, such as: soil covering with straw, addition of organic matter (green manure, compost, biofertilizer), good soil conservation management, crop rotation and intercropping, among other practices (Iriti et al., 2019; EMBRAPA, 2021).

9. Future Perspectives of this Biotechnological Tool

Efficient microorganisms, as they are potential substitutes for chemical products, when exercising biocontrol and/or plant growth promotion actions, favoring the preservation of the environment, have been identified as a viable alternative for ecologically and economically sustainable agricultural production systems.

Brazil has a vast potential for the production and use of biopesticides, however, among the aspects that justify the low exploitation of this sector, there is the high cost of commercial products and their limited availability.

In view of this unfavorable scenario for the use of biological products, it is necessary to develop and promote social technologies that can expand the access and use of biological agents in Brazilian crops.

Knowing that efficient microorganisms represent an important tool for agroecological agriculture and consequently for the sustainable development of agriculture, some work perspectives are suggested, such as the characterization of communities from different places of origin of EM prepared in a homemade way, and the characterization of the rhizospheric community after inoculation of EM in order to identify and determine the microbial core.

There is a need for studies that evaluate dosing and time protocols for EM. Knowing all the benefits of EM for plants, research is needed to demonstrate its efficiency in plant defense.

10. Final Considerations

We are in a new era in agriculture, with the use of microbiological agents as growth promoters and agents in the biological control of diseases and pests in crops. The collection and use of isolates in commercial crops (organic and conventional) can be an efficient control strategy because these populations are naturally adapted to the local environment and specifically aggressive towards pathogen communities present in that agricultural area. This new technique can contribute to the intensive use of these regional isolates, which have greater adaptation to the macro and micro conditions of local agricultural production.

Thus, it is expected that our results highlight the strong potential of this biological control tool to be practiced by farmers and the real possibility of isolating fungi and bacteria in a simple way from the soil of the farm itself.

This technology also creates the possibility for farmers to associate themselves with regional research centers that make it possible to quantify the level of diversity of these biological agents in the field to develop specific strategies for managing diseases and pests in different agroecosystems.

As they constitute potential substitutes for chemical products, when exercising actions of biocontrol and/or promotion of plant growth, favoring the preservation of the environment, they have been identified as a viable alternative for ecologically and economically sustainable agricultural production systems.

This work is expected to disseminate information about the production of bioinputs, contributing to the viability of this production system for both organic and sustainable agriculture. The use of EM is an accessible and low-cost technique, in addition to being easy to prepare on the property.

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